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## KILN FORMED GLASS HEADED GOLF CLUB PUTTER

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### FIELD OF THE INVENTION

This invention relates generally to the manufacture of glass headed golf club by a kiln formed process having a multi-step firing and annealing procedure.

### BACKGROUND OF THE INVENTION

In the game of golf, putters are, traditionally, clubs having club heads of differing masses made from metals, metal-reinforced woods, or metal-covered plastics. Manufacturers precisely weigh and shape the heads of putters in order to give the player the necessary momentum and feel to optimize accuracy when putting.

Like the other materials used, glass can be tailored for weight and shape to enhance accuracy. Glass-headed putters have been vulnerable to even the low impact use that occurs when putting on small greens. The need for higher impact putting has placed glass out of the reach of putter manufacturers. Many glass golf club putter head manufacturing processes use brittle lead crystal-based glass starting materials; these fail in low impact putting on small greens.

Owing to the shortcomings of brittle lead crystal stock, glass putter heads have been limited to primarily decorative putters. Even these must be made sufficiently massive to withstand the relatively low impact putting forces. In short, to date, glass has failed as a putter material.

Nevertheless, the glass-making technologies can allow manufacturing options not readily available in metal alloy or metal composites technologies. Glass-making processes can be altered to use different glass starting materials and different manufacturing procedures which render the physical qualities needed for higher impact



putting yet retain the decorative options unique to glass. Furthermore, kiln formed glass golf club putter heads can be consistently weighted and formed to maximize accuracy in putting and made with a virtually endless variety of decorative colorings and surface bas-relief designs.

5 The strength of a kiln cast glass object depends on the chemical composition of the glass starting materials, the casting production technique, the coefficient of expansion of the melted glass starting materials, and the geometrical shape of the cast object. Glass has the ability to be an optimal putter material due to the great variety available glass materials. With the formability of glass and strength in kiln cast soda lime glass, the opportunity exists to form an endless variety of putters suited to use. The utility depends upon the inherent properties of the chemical composition of the glass chosen. The coefficient of expansion or COE exhibited by a particular glass melt profoundly determines the stability of a glasswork. The COE, also referred to as the coefficient of thermal expansion (CTE), is measured as a decimal fraction percentage change in length per degree of temperature. The COE units for glass are expressed in units of  $10^{-7}\%$  per degree Celsius. Thus, a glass composition having a 90 COE has a coefficient of expansion of  $90 \times 10^{-7}\%$  per degree Celsius. Glass with COE's of 90 and 96 prove to be a suitable material for putters used in high impact putting.

One final concern in selecting glass for putter heads is the method of heating and cooling the glass. The magnitude of the stresses and strains that build up as a melted glasswork undergoes differential cooling from internal regions to external surfaces can be significantly large upon solidification. If that differential in cooling becomes too large, the resulting accumulated stresses and strains will result in the finished glasswork cracking on its own or when bumped with a little force. How prone a given glasswork is to cracking depends on the COE of a given glasswork casting, the casting's shape, and whether the casting is solid or hollow. The accumulating stresses and strains for a given casting can be mitigated by specific annealing processes tailored to a glasswork having a substantially triangular shape and glass materials having compatible COE compositions of 90 or 96.

There is a need to manufacture decorative glass golf putters of virtually any design that are durable enough for regular play. All such putters would clubs having varied shapes and transparencies, colored or clear, that only glass can provide.

#### SUMMARY OF THE INVENTION

The present invention comprises method for the manufacture of kiln-formed glass golf putter heads made from soda-lime based compatible materials and subjected to a multiple stage firing and annealing process. The surface of the golf club putter head can be smooth, or molded with a bas-relief design. The glass can be clear-single colored,

clear-multi colored, clear-to-semi transparent single colored, clear-to-semi transparent multi-colored, single colored opaque, and multi-color opaque. The bas-relief design may be of virtually any design, but commonly might include a golf ball configuration, a golf tee configuration, and a 'birdie' configuration. The result is a more durable, and decorative, glass golf club head having the robustness to strike a golf ball on and beyond small putting greens.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The preferred and alternative embodiments of the present invention are described in detail below with reference to the following drawings.

FIGURE 1A is a front view of the plasticene model.

FIGURE 1B is a top view of the plasticene model with containment dam surrounding the model.

FIGURE 2A is a side view of a negative polyurethane mold.

FIGURE 2B is a side view of the negative polyurethane mold removed from the plasticene model.

FIGURE 3A is a side view of a plastic composite cast poured into the negative polyurethane mold.

FIGURE 3B is a side view of the plastic composite model removed from the negative polyurethane mold.

FIGURE 3C is a side view of the worked plastic composite model with a screw inserted for attaching the model to the working surface.

FIGURE 4A is a side view of a master polyurethane mold.

FIGURE 4B is a side view of the master polyurethane mold with a polyurethane putter pattern.

FIGURE 4C is a side view of the polyurethane putter head model without the bas-relief element.

FIGURE 5A is a side view of the bas-relief element mold with containment dam and model configuration.

FIGURE 5B is a top view of the bas-relief element mold with containment dam and model configuration.

FIGURE 6A is a side view of the polyurethane bas-relief element negative mold.

FIGURE 6B is a side view of the polyurethane bas-relief element negative mold with polyurethane added to create the positive.

FIGURE 6C is a side view of the polyurethane bas-relief element.

FIGURE 7A is a front view of bas-relief decorative elements added to the base polyurethane model secured by pins.

FIGURE 7B is a side view of bas-relief decorative elements added to the base polyurethane model secured by pins.

FIGURE 7C is a top view of bas-relief decorative elements added to the base polyurethane model secured by pins.

5        FIGURE 8A is a side view of the investment material poured over the master polyurethane mold of bas-relief decorative model in which a pin is inserted to create a venting channel.

FIGURE 8B is a side view of the negative investment mold of the bas-relief decorative model that has the venting channel.

10       FIGURE 9A is a side view of the negative investment mold of the bas-relief decorative model with venting channel loaded with soda lime glass.

FIGURE 9B is a side view of the fired investment mold with finished glass putter head.

FIGURE 10A is a side view of the drilling process to prepare a shaft hole.

15       FIGURE 10B is a side view of the shaft being affixed to the shaft hole.

FIGURE 11 is an overview block schematic diagram of the glass putter manufacturing process.

FIGURE 12 is a block schematic diagram of the first glass putter pattern generation process.

20       FIGURE 13 is a block schematic diagram of the second-generation glass putter pattern process.

FIGURE 14 is a block schematic diagram of the third generation glass putter pattern process.

25       FIGURE 15 is a block schematic diagram of the fourth generation glass putter pattern process.

FIGURE 16 is a block schematic diagram of the putter blank without bas-relief (i.e., basic) glass putter pattern process.

FIGURE 17 is a block schematic diagram of the putter blank with bas-relief glass putter pattern process.

30       FIGURE 18 is a block schematic diagram of the pour investment mold glass putter pattern process; and

FIGURE 19 is a block schematic diagram of the invest glass putter manufacturing process.

#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

35       The putter mold and putter as depicted in FIGURES 1-10 are prepared along the schematic flow diagram presented in FIGURES 11-17.

FIGURE 1A: Start with a piece of 1/4" plate glass, Plexiglas, or any smooth non-absorbent nonporous surface as a working surface 23 large enough to build the rough model and surround with a dam, approximately 1" from the model's edge to the wall of the dam. Use plasticene, clay, wax or any suitable modeling material that is nonporous and nonabsorbent 21 to create a rough model and determine an initial form and size.

FIGURE 1B: Create a dam surrounding the model tall enough to cover the model by 1/2" 25. The dam may be made of corrugated cardboard and held in position using small amounts of plasticene around the inside of the dam walls to create a leak proof seal 27 allowing at least an inch of space from the model to the dam wall. Any suitable material can constitute a dam, so long as it will contain, without reacting with, polyurethane casting material.

FIGURE 2A: Fill the dam with a using polyurethane liquid 31 with a Shore hardness of thirty (30) (follow manufacturers' instructions for mixing, pouring and cure time). Once the polyurethane has cured, remove the model by taking apart the dam and gently pulling the polyurethane mold from the working surface 23 and separating it from the model 21.

FIGURE 2B: The resulting void is a negative polyurethane rubber mold 22 of the rough model. Apply a wax based release agent 29, and allow to dry.

FIGURE 3A: Place the negative polyurethane mold on a level-working surface 37. Fill the mold with a 2-part plastic composite material 32. (Follow manufacturers' instructions).

FIGURE 3B: After curing, remove the rough composite plastic model 33 from the polyurethane mold 22.

FIGURE 3C: Use a power sander and/or hand tools to perfect the final shape and surface to create a finished composite master model 34. Attach the model to a smooth working surface 43 using a silicone adhesive or a screw 35 inserted through the bottom of the working surface 35. Build another cardboard dam 25 around the finished composite master plastic model 34 secured using plasticene seals 22. Apply a wax based release agent to the model, and fill with polyurethane 41 and allow to cure.

FIGURE 4A: You now have a master polyurethane base mold 42 for creating subsequent rubber blank putter head models for investing in a glass mold material.

FIGURE 4B: Place the master polyurethane base mold 42 on a level-working surface 53. Apply a wax based release agent to the inside of the master mold 55 and allow to dry. Fill the mold with the polyurethane material 57 and allow to cure.

FIGURE 4C: You now have a putter head blank polyurethane base model 59.

FIGURE 5A: To add bas-relief decorative elements to the blank models you will need to create them using the same polyurethane material as the base model 57.

For example, to create a golf ball element 49, you will need to create a dam 25, 27, twice as tall as the golf ball with at least 1/2" surrounding the ball on the sides. Drill a 1/8" hole in the ball and insert a screw 47 through a small, flat piece of wood 45 long enough to cross the top of the mod dam but not completely cover it. Attach the ball 49 to the screw 47 and center inside the dam cavity. Fill the mold to the desired depth on the ball with the polyurethane material 51 and allow to cure.

FIGURE 5B: Top view of configuration showing placement of screw 47, stick 45 and ball 49 inside the mold dam.

FIGURE 6A: Once the polyurethane has cured 53, remove the dam 25, gently pull the stick and ball from the mold. You now have a polyurethane negative mold of the bas-relief element 53. Place the polyurethane mold of the ball element on a level working surface 23, and apply the wax based release agent to the mold surface and allow to dry 55.

FIGURE 6B: Fill the mold with the liquid polyurethane material 59 and allow to cure.

FIGURE 6C: Once the material has cured, remove the bas-relief element from the mold. You now have the bas-relief element 61 ready to attach to the blank polyurethane putter head blank 57.

FIGURE 7A: Attach the bas-relief golf ball element 61 to the polyurethane putter head blank 57 with a small amount of the polyurethane material 65 held in place by using straight pins 61 until the polyurethane 61 has cured.

FIGURE 7B: Side view of the bas-relief element 59 held in place with the straight pins 61 on the putter head blank 57.

FIGURE 7C: Top view of putter head blank 57 and placement of the bas-relief element 61 on its surface.

FIGURE 8A: After the polyurethane glue has cured 63 and the bas-relief element 59 is in place, remove the straight pins 61. Using a small amount of rubber cement or a spray adhesive applied to the base of the model, place the model on a level working surface 67 and create a dam 27, 25. As a final step, insert a straight pin 71 at the highest point of the bas-relief element 59 to create a vent hole. You are now ready to invest the polyurethane model to create the glass mold. The recommended investment material is gypsum based mold material specially formulated for glass casting. Mix and pour the investment material (according to the manufacturers' instructions) over the polyurethane model 69 and agitate the mold to remove unwanted bubbles and allow the material to set. Approximate setting time is thirty minutes. Once the material has set, remove the dam 25, 27 and the investment mold 65 from the working surface 67 as well as the straight pin 71 and gently pry the polyurethane model 69 from the mold.

FIGURE 8B: Pre-fire the mold according to the manufacturers; instructions. The mold 65 containing the vent hole 73 is now ready to receive the glass.

FIGURE 9A: The glass used to create the putter head has to be compatible. It is recommended to use either COE 90 or COE 96. The finished glass pieces are predominantly clear with a colored transparent clubface element 89 and a colored transparent bas-relief element 83. Once the base glass pieces have been cut and placed in the mold 83, 87, 89 the residual volume of the glass is made up of broken chunks of compatible glass 93. The total amount of glass required for each utter head is dependant on the size of the bas-relief element, with the heaviest weighing 10 ounces and the lightest at 14 ounces (about 284 grams to about 397 grams). Place the mold 65 on a piece of fiber paper 81 large enough to cover the entire mold and set on a kiln shelf 79 and place in the kiln. The filled molds are fired in a side fire kiln using the following schedule: about 6 hours from room temperature to about 634 degrees C, hold for 30 minutes, 1 hour to about 807 degrees C and hold for 40 minutes. Coming down in 20 minutes to 510 degrees C and hold for 2.5 hours, 4.25 hours to 410 degrees C and hold for 2 hours, then 7 hours to 66 degrees C, hold for 5 minutes, then off.

Figure 9B: The finished glass piece 95 in the mold 65. Allow the piece in the kiln to cool to room temperature before removing the glass from the mold material. Wash the remaining mold material from the pieces using warm water and a soft bristle brush. The sides and club face are then ground

Figure 10A: To create the hole 101 in the glass putter head for the shaft, it will have be wet drilled. Place the finished glass piece 95 in shallow plastic pan 105 on a soft piece of folded cloth 103. FIG 10B- The hole 101 is then cleaned out and allowed to dry. Use a small amount of epoxy 111 on the inside of the hole 101 and applied to end of shaft 109 and insert at the desired angle and allow epoxy to set up.

The glass golf club heads are made in a kiln formed process wherein various soda lime glass stocks are assembled for melting in the basic or bas-relief master mold followed by the required annealing process to relieve stresses that would otherwise develop were the glass melt be allowed to cool to quickly. Annealing schedules are dependent on the type of kiln, composition of the glass stocks, the geometry of the cast object, whether the melt is hollow or solid, and the coefficient of expansion exhibited by the starting glass stocks. The purpose of the particular schedules is to assure that the temperature differential between the core and the surface is kept to within ten percent.

Into the basic or bas-relief mode are placed soda lime glass stocks having compatible COEs of either 90 or 96 but not a mixture of these COE's. There is no need for the coloration or transparency of the glass stock to match. The COE is the single constant necessary for the annealing to remove the stresses that accumulate due to

unequal cooling within the head of the putter. How the glass stocks are positioned is dependent only upon the desired decorative effect to be achieved for the putter head.

To assure a homogenous glass head, the annealing schedule of melted soda lime glass is critically controlled to match the 90 COE glass transition temperatures for the putter head melts having a mass range of about 10 to 14 ounces (about 284 grams to about 397 grams). Using soda lime glass having a 90 coefficient of expansion (COE), or thermal expansion coefficient of  $90 \times 10^{-7}\%$  or greater, the glass melts are subjected to a multi-stage firing and annealing and thermal tempering process in a kiln. The result is that a highly decorative golf club head having superior physical qualities.

The 90 COE transition temperatures and the thermal mass of the putter head determines the heating and cooling schedules for forming the head. In a span of about 23 hours, glass golf club heads are subjected to a combined firing and annealing thermal tempering process composed of eleven segments as follows:

- 1) about six hours in gradual and uniform advance from room temperature to about 634 degrees C;
- 2) hold the temperature for about 30 minutes at 634 degrees C;
- 3) about one hour raise the temperature of the glass to about 807 degrees C;
- 4) hold the temperature for about 40 minutes at about 807 degrees C;
- 5) cool the head for about 20 minutes to about 510 degrees C;
- 6) hold the temperature for about two hours at 510 degrees C;
- 7) allow the glass head to cool gradually and uniformly for about four and a half hours to 410 degrees C;
- 8) hold the temperature for about two hours at 410 degrees C;
- 9) allow the glass head to cool gradually and uniformly for about seven hours to about 66 degrees C;
- 10) hold the temperature for about 5 minutes at about 66 degrees C;
- 11) then turn the kiln off and allow the glass putter heads to cool to room temperature.

The results are heads having sufficient robustness to play a more rigorous round of golf on larger putter greens. The golf club heads are made to any desired physical appearance. The heads may be clear, single colored, multi-colored, semi-transparent, multi-colored semi-transparent, and opaque. The head may be smooth without a bas-relief design, or with any desired bas-relief design. A bas-relief design would include a golf ball protruding from the top of the club. The result is that of a highly decorative golf club head having superior physical qualities to those glass putter heads not prepared by the foregoing firing and annealing process.



5 Glass putter heads are washed in warm water or equivalent air-dryable solvent and scrubbed with a soft bristle brush to remove any residual mold material. The heads then undergo a polishing procedure using a wet belt sander with grit size ranging from about 100 to about 1200. A hole for the shaft is made using a 1/8-inch diamond drill to a depth of 1/2 inch, widened with a 1/4-inch diamond bit, followed by further widening with a 3/8 inch bit to the 5/8-inch depth. The hole is washed clean and allowed to dry. A small amount of epoxy glue is placed in the hole and the shaft inserted and held until the epoxy glue sets.

10 While the preferred embodiment of the invention has been illustrated and described, as noted above, many changes can be made without departing from the spirit and scope of the invention. For example, non-triangular shapes can be used for the putter heads as long as the glass mixture is 90 COE or 96 and that the mass melt is about 284 grams to about 397 grams.. Accordingly, the scope of the invention is not limited by the disclosure of the preferred embodiment.

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